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Patent Application for

System and Method of Fluid Transfer Using Devices with Rotatable Housings

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Cross Reference to Related Applications

The present application is a continuation in part application from the U.S. Patent Application titled "Pressurized Vapor Cycle Liquid Distillation" with inventors David F. Bednarek, Jason A. Demers, Timothy P. Duggan, James L. Jackson, Scott A. Leonard, David W. McGill, and Kingston Owens, filed November 13, 2003 (serial no. not yet assigned), which is hereby incorporated herein by reference.

Technical Field

The present invention relates to transferring fluids between systems and within a system, and more particularly to fluid transfer systems that include a rotatable housing.

Background Art

Pumps are a common means to transfer fluids within a system or between two systems. The use of pumps, however, has disadvantages. Pumps are typically dynamic devices with a plurality of moving parts that are subject to aging, wear, and breakage. Thus, pumps require continuous monitoring and maintenance, which requires shut down of a system and labor to service and monitor the pump. Pumps also have a finite operating lifetime; even with constant maintenance, sudden failure of the pump without warning may occur. Finally, pumps require continuous power in order to operate. Such power usage may expend a substantial amount of energy, which can substantially decrease the energy efficiency of a process. Thus, a need exists for devices and methods of transferring fluids that reduce the maintenance effort required and failure rate of pump devices, while utilizing less power in order to achieve fluid transport.

Summary of the Inventi n

A fluid transfer system, in accord with a first embodiment of the invention includes a rotatable housing that defines at least a part of a boundary of a first chamber; a fluid-drive element attached to the rotatable housing; and a conduit for transferring fluids. The fluid-drive element is configured to force fluid through the conduit when the rotatable housing rotates. The rotatable housing may include a shaft to which the fluid-drive element is attached, and may also be a portion of a liquid ring pump.

Other related embodiments of the invention may nest the first chamber in a second chamber. In such embodiments, the fluid drive element may be an impeller of a centrifugal pump, with the impeller located outside the first chamber. A pitot tube may be attached to a stationary boundary of the second chamber to transfer fluid. The pitot tube may be threaded through a hollow portion of a shaft of the rotatable housing.

In a second embodiment of the invention, a fluid transfer system includes a rotatable housing that defines at least a part of a boundary of a first chamber; and a pitot tube for transferring fluids, the pitot tube configured such that fluid is driven into the pitot tube when the rotatable housing rotates. The pitot tube may be attached to or detached from the rotatable housing. The system may further include a partially enclosed track attached to the rotatable housing for holding fluid, wherein the pitot tube is configured to transfer fluid from the partially enclosed track when the rotatable housing rotates. The rotatable housing may be a portion of a liquid ring pump. The system may also include a second chamber capable of holding fluid, wherein the first chamber is nested in the second chamber, and a pitot tube connects the first chamber and the second chamber.

A fluid transfer system in third embodiment of the invention includes a rotatable housing defining at least a part of a boundary of a first chamber; a second chamber capable of holding fluid, the first chamber being nested in the second chamber; and a conduit connecting the first chamber and the second chamber, wherein the conduit is configured such that fluid is driven through the conduit when a pressure difference exists between the first chamber and the second chamber. The rotatable housing may be a portion of a liquid ring pump. Fluid may be driven from the second chamber to the first chamber when pressure in the second chamber is higher than pressure in the first chamber.

A fluid transfer system according to a fourth embodiment of the invention includes a

rotatable housing defining at least a part of a boundary of a first chamber capable of holding fluid; a second chamber capable of holding fluid, the first chamber nested in the second chamber; a conduit for transferring fluid between the first chamber and second chamber; and a baffle attached to a stationary boundary of the second chamber, the baffle configured to keep a conduit opening submerged in fluid in the second chamber when the rotating housing rotates. The rotatable housing may be a portion of a liquid ring pump. The system may further include a pump configured to drive fluid through the conduit between the first chamber and the second chamber.

In a fifth embodiment of the invention, a fluid transfer system includes a rotatable housing defining at least a part of a boundary of a first chamber; a second chamber capable of holding fluid, the first chamber being nested in the second chamber; and a conduit connecting the first chamber and the second chamber, wherein the conduit is configured such that fluid is driven through the conduit by a pump.

Embodiments of the invention may also be directed toward methods of transferring fluid between two containers. Such methods include the steps of providing a conduit to connect a first container and a second container, each container holding fluid; and rotating at least part of a boundary of the first container to drive fluid into the conduit to transfer fluid between the first container and the second container. Alternatively, a method of transferring fluid between a liquid ring pump and a fluid reservoir includes the steps of providing a liquid ring pump with a rotatable housing; providing a conduit to connect the liquid ring pump with a fluid reservoir; and rotating the rotatable housing to drive fluid into the conduit to transfer fluid between the liquid ring pump and the fluid reservoir.

Brief Description of the Drawings

The foregoing features of the invention will be more readily understood by reference to the following detailed description, taken with reference to the accompanying drawings, in which:

Figure 1 is an isometric view of a liquid ring pump, the features of which may be used in conjunction with some embodiments of the invention;

Figure 2 is a side-view of various embodiments of the invention that include a rotatable housing nested in another chamber with radially oriented baffles, the housing attached to pitot tubes to transfer fluid;

Figure 3 is a side-view of embodiments of the invention which utilize a rotatable housing that includes a shaft, the shaft attached to a fluid-drive element to displace fluid into a tube to transfer fluid;

Figure 4 is a side-view of embodiments of the invention that include a rotatable housing that includes a shaft, the shaft attached to an impeller of a pump to displace fluid, and the use of a normal pump; and

Figure 5 is a side-view of embodiments of the invention that utilize a tube to transfer fluid from one region to another based on a pressure difference between the two regions.

Detailed Description of Specific Embodiments

Definitions. As used in this description and the accompanying claims, the following terms shall have the meanings indicated, unless the context otherwise requires:

Fluid refers to a liquid, a gas, any mixture of a liquid and a gas, or a liquid entrained with gases and/or solids. In many of the embodiments described herein, the fluid transfer systems typically transfer liquids, or liquids with amounts of gases dissolved or present as bubbles. The systems, however, are not necessarily limited to transport of the specific fluids described therein.

A conduit is a device capable of directing the flow of fluid in a path from at least one location to another location. Conduits are not restricted in terms of the types of shapes, sizes, and materials that may be utilized. Conduits may enclose the path that fluid is directed along, or may be partially exposed to the environment. Non-limiting examples of conduits include pipes, ducts, tubes, channels, and canals. Some embodiments of the invention as described herein, refer to the use of tubes. Such embodiments, however, may be practiced with any appropriate conduit, as is readily understood by those skilled in the art. For example, a pitot tube may be any appropriate conduit for directing a fluid, which may be undergoing convection, from one location to another.

In some embodiments of the present invention, a rotatable housing is used to drive fluid into a tube to transfer the fluid from one place to another. The rotatable housing may be part of a larger system. For example, a liquid ring pump **100**, as depicted in Figure 1 and described in the U.S. Patent Application titled "Pressurized Vapor Cycle Liquid Distillation" with inventors David F. Bednarek, Jason A. Demers, Timothy P. Duggan, James L. Jackson, Scott A. Leonard, David W. McGill, and Kingston Owens, filed November 13, 2003 (serial no. not yet assigned), may include a rotatable housing **10** to help improve the efficiency of the liquid ring pump **100**. Fluid transfer between a fluid reservoir **30** and an inner chamber **12** is regulated to maintain the appropriate amount of fluid in each section **12**, **30** of the pump **100**.

In Figure 1, fluid transfer between the reservoir **30** and an inner chamber **12** is achieved using a siphon pump **32**. Alternatively, other types of pumps may be used to transfer fluid. For example, a centrifugal pump **385** may be used to transfer the fluid, as depicted in Figure 4. Fluid transfer, however, may be achieved without the use of a conventional pump. Thus, embodiments of the invention may enable fluid transfer without the need to provide a separate head source devoted to driving fluid flow. In some embodiments of the invention, the motion of a rotating housing is used to drive a fluid-drive element, causing fluid transfer by forcing fluid through a tube. Other embodiments of the invention attach a pitot tube to the rotating housing, the movement of the housing driving fluid transfer through the pitot tube. In some embodiments of the invention, the rotatable housing may include a rotatable housing shaft that rotates in sync with the outer housing (such as shown by an element **53** in Figure 1); the pitot tube or fluid-drive element may be attached to the rotatable housing via attachment to the rotatable housing shaft. Still other embodiments of the invention rely on a pressure difference between two containers to drive fluid transfer between the containers. Preferred embodiments of the invention include a chamber being nested in another chamber, fluid transfer taking place between the chambers. Some embodiments of the invention demonstrating fluid transfer are made with reference to a liquid ring pump with a rotatable housing nested in an external housing, an example of which is depicted in Figure 1. The use of such embodiments, however, is not limited to the context of liquid ring pumps or nested containers as specifically described herein.

Some embodiments of the invention are directed to the use of pitot tubes to drive the flow of fluids between an inner liquid ring region **12** of a liquid ring pump and an outer, lower reservoir region **30** enclosing the inner region as depicted in Figure 2. Such embodiments may be used to replace devices such as the siphon pump utilized in Figure 1 to move fluid from the reservoir **30** into the chamber **12**. The flow rate of fluid transport through the pitot tubes is a function of the speed of the housing **10** rotation, the length of the pitot tube, the total vertical displacement achieved by the pitot tube, and the underlying fluid properties.

In one embodiment of the invention depicted in Figure 2, a pitot tube **310** transfers fluid from the reservoir **30** into the chamber **12**. The pitot tube **310** is attached and stationary relative to a rotating housing **10** such that the tube **310** rotates as the housing **10** rotates. The opening **311** of the pitot tube **310** is oriented such that the face of the opening **311** is driven through the reservoir fluid **330** as the housing **10** rotates. Fluid is thus pushed in the opening **311**, through the tube **310**, and out the other opening **312** into the liquid ring chamber **12**.

Embodiments of the invention that transfer fluid from the reservoir region **30** to the inner chamber **12** may utilize one or more baffles that are attached to the stationary, exterior housing **25** in the reservoir region **30** as shown in Figure 2. The baffles are configured to disrupt the flow of fluid induced by the rotation of the housing **10**. In a particular embodiment of the invention, baffles **340** are radially oriented to keep a tube opening **311** submerged in fluid **330** by altering the fluid flow induced by the rotation of the housing **10**, as depicted in Figure 2. Without baffles, a circulation pattern of fluid in the reservoir region **30** may expose opening **311** to a region without liquid causing gas to be entrained into the liquid ring region or, due to relative fluid motion, the opening **311** would not be driven into the fluid with sufficient relative velocity to push the fluid up the tube **310.** Though the use of baffles is illustrated with the use of a pitot tube as shown in Figure 2, other embodiments of the invention may utilize baffles to maintain tube opening submersion when the fluid in the tube is driven by other mechanisms (e.g., pumps).

In another embodiment of the invention depicted in Figure 2, a pitot tube **320** is positioned to protrude from the chamber **12** to transfer fluid into the chamber **12**. A partially enclosed track **325** is attached to the rotating housing **10** to capture liquid that leaks from the chamber **12** as the housing **10** rotates. The pitot tube **320** is detached from the rotatable

housing **10** such that the tube **320** maintains a fixed, or relatively fixed position, vis à vis the exterior housing **25**. The pitot tube **320** is oriented such that rotation of the housing **10** drives the fluid into the face of opening **321**. Fluid moves through the pitot tube **320** and out the other opening **322**, to be deposited into the chamber **12.** Alternatively, a pitot tube (not shown) located in the upper region of the chamber **12** transfers fluid from the liquid ring pump region into the reservoir **30**.

Another embodiment of the invention utilizing pitot tubes in depicted in Figure 3. In this embodiment, a fluid-driving element **370** is attached to a rotatable housing **10** through a rotating housing shaft **50**. Alternatively, the fluid-drive element **370** may be affixed to the floor of the rotatable housing **10**. Rotation of the housing **10** moves the fluid-driving element through fluid **330** contained within the reservoir **30**, causing the fluid **330** to circulate. Pitot tube **390** is attached to a stationary boundary **25** of the reservoir **30**. The pitot tube **390** is oriented such that circulating fluid **330** is driven into the entrance **391** of the pitot tube **390**, and out the back end **392**, where the transferred fluid is deposited into the chamber **12**. Alternatively, a pitot tube **315** may be threaded through a hollow shaft **50**, the shaft **50** being attached to the rotatable housing **10**. Thus, the fluid-driving element **370** drives fluid **330** into face **316**, fluid exiting the tube **315** out the opposite face **317** and into the bottom of the chamber **12**. Pitot tubes may also be configured to drive fluid out of the reservoir **30** and into other regions of a system.

In a related embodiment of the invention, a fluid-driving element may be an impeller of a centrifugal pump which is used to transfer fluids from one place to another. In an embodiment of the invention depicted in Figure 4, the rotatable housing **10** is connected to an impeller **350** through the shaft **51** of the rotatable housing such that rotation of the housing **10** causes the impeller **350** to rotate. Alternatively, the impeller may be attached to the floor of the rotatable housing **10**. The impeller **350** is housed in a centrifugal pump **380**, and configured to draw fluid from the reservoir **30**, and displace the fluid into the liquid ring chamber **12** via tube **381**. Other pieces of the centrifugal pump **380** (e.g., the housing of the pump) may be configured not to rotate with the housing **10**. The impeller **350** may be any shape that results in fluid being drawn from the reservoir **30** to the inner chamber **12**. A conventional centrifugal pump **385**, or any other appropriate pump, may also be used instead of the pump **380**.

Figure 5 depicts another embodiment of the invention wherein passive pressure difference may be utilized to drive fluid flow. If the pressure in reservoir **30** is greater than the pressure in chamber **12**, a tube **360** may be used to pass fluid from the reservoir **30** to the chamber **12,** the pressure difference driving the flow. The reservoir **30** and chamber **12** are each sealed to sufficiently maintain a pressure difference between the chambers, the characteristics of the tube **360** and the pressure difference dictating the flow rate between the two containers. The tube used to transfer fluid between the chamber **12** and the reservoir **30** may feed fluid through the bottom of the rotatable housing **10**, or through to the top of the chamber **12**, as shown with tube **365**. These embodiments of the invention may be practiced with or without the rotating housing **10**. A pressure difference may also be used to drive fluid motion to other parts of a system as well.

In some of the embodiments of the invention previously described where a liquid ring pump may be utilized, fluid transfer may be enabled with the liquid ring pump being positioned in various orientations. Thus, in accord with embodiments of the invention, fluid transfer may take place whether the liquid ring pump is positioned horizontally or vertically. The precise positioning of tubes, fluid-drive elements, and other features of the fluid transfer systems may be adjusted depending upon the orientation of the liquid ring pump.

While the invention has been described in connection with specific embodiments thereof, it will be understood that it is capable of further modification as will be apparent to those skilled in the art. All such variations and modifications are intended to be within the scope of the present invention as defined in the specification.